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LIST OF ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
%D	Percent Difference
µg/L	Microgram(s) per Liter
<u>AOC</u>	<u>Area of Concern</u>
ARCADIS	ARCADIS U.S., Inc.
BFB	4-Bromofluoro-benzene Tune Verification
bgs	Below Ground Surface
CCV	Continuing Calibration Verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of Concern
CSM	Conceptual Site Model
CVOC	Chlorinated Volatile Organic Compound
DCE	Dichloroethene
<u>DO</u>	<u>Dissolved Oxygen</u>
DoD	Department of Defense
DQI	Data Quality Indicator
DQO	Data Quality Objective
DRMO	Defense Reutilization Marketing Office
EA	EA Engineering, Science, and Technology, Inc., PBC
ELAP	Environmental Laboratory Accreditation Program
FS	Feasibility Study
ft	Foot (feet)
GC/MS	Gas chromatography/mass spectrometry
GPS	Global positioning system
HPT	Hydraulic Profiling Tool
ICAL	Initial Calibration
ICV	Initial Calibration Verification
IS	Internal Standard
L	Liter(s)
LCS	Laboratory Control Sample
LOQ	Limit of Quantitation
LTM	Long-Term Management
LUC	Land Use Control
mg/kg	Milligram(s) per Kilogram

mL	Milliliter(s)
MNA	Monitored Natural Attenuation
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NJDEP	New Jersey Department of Environmental Protection
NJSWQC	New Jersey Surface Water Quality Criteria

ORP Oxidation Reduction Potential

PAH	Polycyclic Aromatic Hydrocarbons
PAL	Project Action Limit
PCB	Polychlorinated Biphenyl
PCE	Tetrachloroethene
PDB	Passive Diffusion Bag
PID	Photoionization Detector
PICA	Picatinny Arsenal
PRB	Permeable Reactive Barrier
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RA-O	Remedial Action-Operations
RCRA	Resource Conservation and Recovery Act
RDX	Cyclotrimethylenetrinitramine
RI	Remedial Investigation
<u>RIR</u>	<u>Reference Intensity Ratio</u>
ROD	Record of Decision
RPD	Relative Percent Difference
RSD	Relative Standard Deviation
RSL	Regional Screening Level

SC Specific Conductance

SCL	Site Cleanup Level
SIM	Selected Ion Monitoring
SOP	Standard Operating Procedure
SVOC	Semivolatile Organic Compound

TCA	<u>1,1,1-Trichloroethane</u> Trichloroethane
TCE	<u>Trichloroethylene and/or Trichloroethene</u> Trichloroethane
TNT	Trinitrotoluene

UFP	Uniform Federal Policy
USACE	United States Army Corps of Engineers
USAEC	United States Army Environmental Command

USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UXO	Unexploded Ordnance

VC	Vinyl Chloride
VOA	Volatile Organic Analyte
VOC	Volatile Organic Compound

<u>XRD</u>	<u>X-Ray Diffraction</u>
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ZVI	Zero-valent Iron
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CHAPTER 1: EMERGING CONTAMINANT EVALUATION (1,4-DIOXANE AND PERCHLORATE)

QAPP Worksheet #10A: Conceptual Site Model

The CSM provides a framework for understanding the distribution and behavior of the emerging contaminants 1,4-dioxane and perchlorate in the groundwater and it provides descriptions of the site-specific RA-Os. Based on previously identified contaminants of concern at several sites at Picatinny Arsenal, recommendations for these emerging contaminants were made in the Fifth Five-Year Review Report (USACE 2016). General installation background, operational history, and natural resource information is presented in Worksheet 10 of the 2016 RA-O and LTM QAPP (EA 2016a).

Emerging Contaminant Evaluation

1,4-Dioxane

The synthetic industrial chemical 1,4-dioxane often occurs at sites contaminated with chlorinated solvents, particularly 1,1,1-trichloroethane (1,1,1-TCA), because of its use as a stabilizer for chlorinated solvents (USEPA 2017a). When the use of 1,1,1-TCA was phased out in 1995, the use of 1,4-dioxane as a stabilizer also ceased; however, 1,4-dioxane is currently used in the manufacturing of pharmaceuticals and polyethylene terephthalate (PET) plastic, and is a by-product in many goods. Delineated chlorinated solvent plumes and existing monitoring networks have been frequently found to contain 1,4-dioxane.

Completely soluble in water, 1,4-dioxane is a likely human carcinogen that is found in groundwater and is highly mobile, with only weak sorption to soil particles. While found to be relatively resistant to biodegradation, 1,4-dioxane has not been noted to bioaccumulate, biomagnify, or bioconcentrate in the food chain (USEPA 2017a). NJDEP has established a groundwater quality criterion of 0.4 micrograms per liter (µg/L) for 1,4-dioxane (NJDEP 2018).

At PICA, there are two RA-O sites at which 1,4-dioxane sampling will occur due to historical detections of 1,1,1-TCA, Group 3 and Area E. The Fifth Five-Year Review Report (USACE 2016) also recommended that 1,4-dioxane sampling be conducted at Area D, specifically in well D-PW-131. Drinking water well D-PW-131 was sampled for 1,4-dioxane in May 2016 and September 2017; 1,4-dioxane was not detected in the water during either sampling event. American Water will be sampling for 1,4-dioxane annually going forward.

Group 3 (PICA-008): Sites 1, 2, and 4

Group 3 is approximately 40 acres in size and encompasses 3 Sites (Sites 1, 2, and 4), which are located in the east-central portion of PICA (Figure 10A-1). Sites 1 and 4 were formerly used as a Naval Air Rocket Test Station area. Site 2 was a test area for rocket engines, a photographic lab, a passivation house, and a sewage treatment facility. COCs identified in groundwater include the chlorinated volatile organic compounds (CVOCs) tetrachloroethene (PCE),

Given the historical practices at some of the Mid-Valley sites and the potential exposure concerns identified in the Fifth Five-Year Review (USACE 2016), a subset of monitoring wells will be analyzed for perchlorate. The subset will include six monitoring wells: two along the longitudinal axis of the plume and/or wells representing the areas with highest concentrations of explosives, three locations downgradient, and one background location. This action is consistent with the selected remedy detailed in the ROD, which included measures intended to prevent human exposure to contaminated groundwater that would cause unacceptable risk and to restore groundwater to its use as a drinking water source.

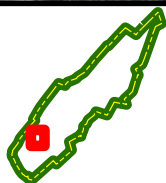
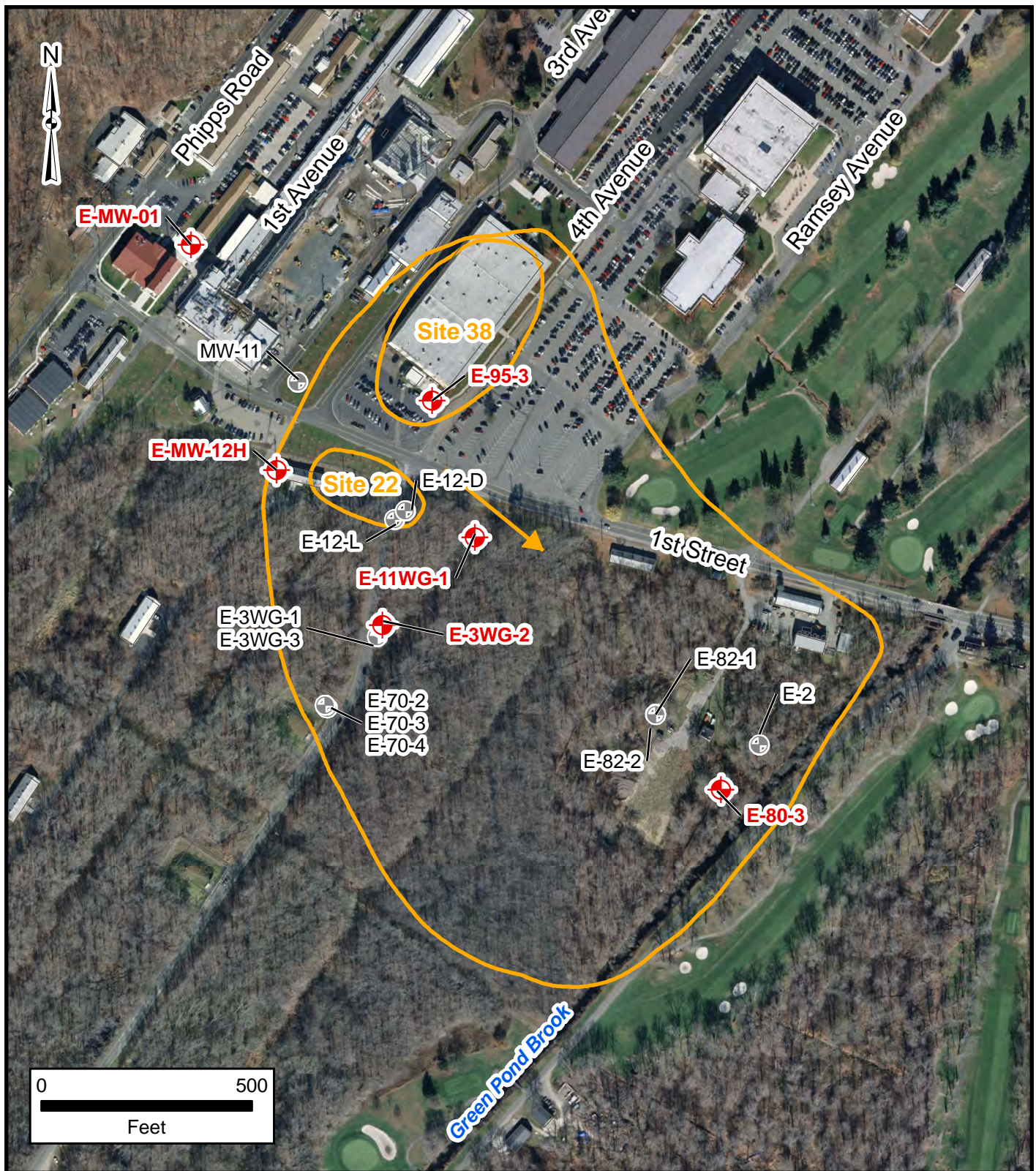
Group 1 (PICA-079): Sites 40, 93, 156, and 157

Group 1 is approximately 4 acres and includes Sites 40, 93, 156, and 157, which are located in the central portion of PICA along the eastern shore of Picatinny Lake (**Figure 10A-4**). Site 40 consists of Buildings 809 and 810; Building 809 was originally constructed for use as a large caliber projectile washout facility, and Building 810 was originally intended as an operating facility. Currently the Buildings are respectively used as an explosives wastewater treatment plant and a melt-pour research facility.

Site 93 historically consisted of Buildings 800 and 807. Building 800 has been demolished. The only building currently standing at Site 93 is Building 807, which was originally constructed as a receiving, cleaning, and inspection facility, but is currently used for cold storage and for staging packing materials for Building 820 (Site 157). Site 156 consists of Buildings 813, 816, and 816-B. Building 813 was originally constructed for use as a production facility for large-caliber projectiles. Currently, this building is utilized as a remote automated control facility for Building 810 (Site 40). Site 157 consists of two separate areas, a northern and southern area. The southern area of Site 157 is located northeast of Site 93 and includes Buildings 823 and 824 that were used as loading plants. Building 823 was also used to treat operational wastewaters. The northern area of Site 157 includes Building 820, which was also used as a loading plant. Building 820 has been reactivated as an ammunition repack and surveillance facility.

The Group 1 Sites were divided into four separate areas of remediation based on site- and media-specific COCs. Therefore, analytical evaluations were conducted for each of the following: explosives in soil, arsenic and polycyclic aromatic hydrocarbons (PAHs) in soil, PCBs in soil, and explosives in groundwater. As discussed in the Fifth Five-Year Review (USACE 2016), explosive related impacts to Sediments located within Group 1 Sites were initially to beare being evaluated as part of the Picatinny Lake Feasibility Study (FS). However, this component of the Lake Picatinny FS was subsequently removed and is now being addressed under Group 1 Sites (PICA-079). sSurface water and sediment monitoring are being conducted as part of the selected groundwater remedy to monitor impacts to Picatinny Lake as a result of existing groundwater contamination for 2,4,6-TNT and RDX.

The groundwater remedial action objectives established for Group 1 in the ROD were developed to prevent human exposure to contaminated groundwater that would cause unacceptable risk and to restore groundwater to its beneficial use as a drinking water source. Given the historical practices at some of the Group 1 sites, the potential exposure concerns identified in the Fifth Five-Year Review (USACE 2016), and the need to remain consistent with the established



Area E (PICA-077)

Groundwater Flow Direction



Monitoring Well to be Sampled



Other Monitoring Well

QAPP Worksheet #18A: Sampling Locations and Methods

Sample Locations	Matrix	Depth (feet [ft] below ground surface [bgs])	Type	Frequency ⁴ / Analytical Group	Sampling SOP	Rationale for Sampling Location
Group 3 (Sites 1,2, and 4)						
Four existing monitoring wells: 2MW-5 (downgradient) 2MW-14 (downgradient) 2MW-17 (source area) 2MW-26 (source area)	Groundwater	Various	HydraSleeve / Low Flow	2018: one round of 1,4-dioxane sampling from four wells; two wells near/downgradient of the source area at Site 2 and the two wells furthest downgradient.	SOP013/ 013A, SOP048	Analysis of emerging contaminants in groundwater.
Area E (Sites 22 and 38)						
Six existing monitoring wells: E-MW-01 (background) E-11WG-1 (downgradient of Bldg. 95) E-3WG-2 (downgradient of impoundment) E- 82 -180-3 (additional downgradient) E-95-3 (near Bldg. 95) E-MW-12H (near impoundment)	Groundwater	Various	HydraSleeve / Low Flow	2018: one round of 1,4-dioxane sampling from six wells; two wells near and downgradient of the source area of the former surface impoundment, two wells near and downgradient of the former underground tank in Building 95, a background well, and an additional downgradient well.	SOP013/ 013A, SOP048	Analysis of emerging contaminants in groundwater.
Group 1 (Sites 40, 93, 156, and 157)						
Six existing monitoring wells: 40MW-2 (downgradient) 40MW-3 (source area) 40MW-6 (downgradient) 93MW-2 (upgradient) 157MW-3 (downgradient) 157MW-4 (cross gradient)	Groundwater	Various	HydraSleeve / Low Flow	2018: One round of sampling at six wells for perchlorate (background, source area, downgradient)	SOP013/ 013A, SOP048	Analysis of emerging contaminants in groundwater.

⁴ Sampling frequency is subject to change based upon the results of monitoring. Any changes made to sampling frequency will be documented in the annual reporting process.

Sample Locations	Matrix	Depth (feet [ft] below ground surface [bgs])	Type	Frequency ⁴ / Analytical Group	Sampling SOP	Rationale for Sampling Location
Mid-Valley (Study Areas F, G, H, and L)						
101MW-5 (background) 104MW-6A (downgradient) 138MW-5B (downgradient) <u>6MW-4D (Site 6 Shell Burial Ground source area)</u> <u>17MW-5 (RDX Plume source area)</u> <u>5MW-4 (Site 5 Shell Burial Ground source area)</u> 17MW-4 (source area) 17MW-5 (deep source area) DM6-1 (downgradient)	Groundwater	Various	HydraSleeve / Low Flow	2018: One round of sampling at six wells for perchlorate (focused on locations in RDX plume <u>and Shell Burial Ground</u>)	SOP013/ 013A, SOP048	Analysis of emerging contaminants in groundwater.

QAPP Worksheet #19A & 30A: Sample Containers, Preservation, and Hold Times

Laboratory: SGS-Accutest Laboratories,
4405 Vineland Road, Suite C-15
Orlando, FL 32811
Point-of-Contact: Ariel Hartney <Ariel.Hartney@sgs.com>

List any required accreditations/certifications: DoD Environmental Laboratory Accreditation Program (ELAP)-Certified, New Jersey ELAP-Certified (Certifications provided in Appendix A; expire 12/15/2018 and 6/30/2019, respectively).

Sample Delivery Method: FedEx shipment.

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method	Sample Volume	Containers (number, size, and type) ^(a,b)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/analysis)	Data Package Turnaround
Aqueous	SVOC SIM	Various	SW-846 3510C/8270D SIM OP059/MS008	2,000 milliliters (ml)	Two 1,000 ml amber bottles	Cool 4 degrees Celsius ($^{\circ}\text{C}$) \pm 2 $^{\circ}\text{C}$,	7 days from collection to analysis; 40-day analytical holding time from extraction	Standard – 15 Days
Aqueous	Perchlorate by LC/MS/MS	Various	SW-846 6850/MS013	250 ml	Two 125-mL HDPE, filled with 1/3 headspace	Cool 4 $^{\circ}\text{C}$ \pm 2 $^{\circ}\text{C}$	28 days from collection to analysis	Standard – 15 Days
<p>a. Sample size is a minimum; the containers listed will be filled to compensate for any required re-analysis or re-extractions. For samples requiring MS/MSD containers listed should be tripled.</p> <p>b. It should be noted that extra sample containers will be provided by the laboratory to account for the possibility of breakage during shipment or in the field prior to sampling.</p>								

QAPP Worksheet #20A: Field Quality Control Summary

The following table represents the sample numbers for the sites receiving emerging contaminant environmental sampling. Quality assurance (QA)/QC sample requirements are based on the number of samples collected at each individual site; because of this, the number of field duplicates and MS/MSD samples is not always 10 or 20 percent of the number of native samples presented in the table. Sites that also receive a second round of sampling (as noted in Worksheet #18A) will follow the same QA/QC collection rules as presented below (one field duplicate per 10 parent samples and one MS/MSD collected per 20 parent samples).

Matrix	Analyte/Analytical Group	Native Samples	Field Duplicates ^(a)	MS/MSD ^(b)	Field Equipment Blanks ^(c)	Trip Blanks ^(d)	Total Number Samples to Lab
Group 3							
Groundwater	1,4-Dioxane	4	1	1	1	Not Applicable	7
Area E							
Groundwater	1,4-Dioxane	6	1	1	1	Not Applicable	9
Mid-Valley							
Groundwater	Perchlorate	6	1	1	1	Not Applicable	9
Group 1							
Groundwater	Perchlorate	6	1	1	1	Not Applicable	9
a. One field duplicate will be collected per 10 parent samples on a site by site basis. b. One MS/MSD sample will be collected per 20 parent samples on a site by site basis. c. One field-equipment blank will be collected per sampling event or every 5 percent of samples, at a minimum. d. One trip blank per sample cooler that includes VOC samples.							

Groundwater

In the area southwest of the PRB wall, one round of *in situ* groundwater sampling for VOCs will be conducted using roto-sonic drilling in conjunction with HPT in 20-ft intervals at five locations to help determine mass flux into the PRB and further delineate the plume. Concurrently, *in situ* screening using the HPT will be used to collect relative conductivity measurements to assist in determining intervals of higher porosity/mass transport. Two sets of clustered wells (shallow, mid, and deep) will be installed adjacent/southwest to D-PRB-09 to delineate CVOCs in groundwater southwest of the PRB.

In areas upgradient and downgradient of D-92-3, which is a plume centerline well with TCE concentrations consistently above the Site Cleanup Level (SCL), two transects of five boreholes each will be installed using roto-sonic drilling methods and HPT to provide horizontal and vertical delineation of TCE. *In situ* aqueous grab samples for VOC analysis will be collected every 20 ft bgs to refusal, targeting 100 ft bgs (five samples per boring). There are currently no vertical/horizontal delineation data available near well D-92-3. Following analysis of HPT and *in situ* results, a data report will be prepared to identify areas of elevated CVOCs at which two well clusters (shallow, mid, and deep) will be installed to provide definitive groundwater results. Groundwater results will be used to update the CSM, evaluate mass flux of contaminants, and ~~evaluating-evaluate~~ potential alternative remedies. The new monitoring well clusters will also be used as future performance monitoring locations.

Following the installation of the well clusters and analysis of *in situ* groundwater results in a separate data report, a comprehensive sampling and gauging event of 17 current PRB wells and the 12 newly installed wells (clusters) will be conducted. The data report will also identify six monitoring wells from which to collect biological reductive dechlorination parameters (methane/ethane/ethene, ammonia, sulfate/sulfur, nitrate/nitrogen, dissolved iron, and manganese). Groundwater sampling methods in the monitoring wells will include use of HydraSleeves, and/or traditional USEPA low-flow groundwater sampling procedures (as applicable, see Worksheets #17B and #18B). Additionally, the data report will recommend three wells for use of bio-traps to collect microbial samples and assess the available microbial community structure.

Soil

While the roto-sonic drill rig is onsite, two soil borings will be collected within the PRB to visually inspect for biofouling and silting that may be impacting PRB performance. Up to three samples to be analyzed for VOCs will be collected from each core, targeting intervals of visual impacts and/or areas that register highest on the photoionization detector (PID). One sample from each boring will also be submitted for iron oxyhydroxide (rust), calcium carbonate (chalk), iron sulfide (pyrite), and porosity analysis.

Surface Water

As part of the PRB evaluation, five surface water samples will be collected from Green Pond Brook. Surface water samples will be collected from mid-stream at mid depth by immersing the

QAPP Worksheet #17B: Sampling Design and Rationale

Sampling is required at Area D as part of the PRB and upgradient CVOC evaluations and includes the collection of groundwater and surface water for laboratory analyses of site-related COCs (VOCs). Supplemental to site-related COCs, biological reductive dechlorination parameters will be sampled in six monitoring wells, and three wells will be sampled for microbial community structure.

Sampling methodologies for HydraSleeves and/or traditional USEPA low-flow groundwater procedures will follow those established in the *Final Uniform Federal Policy-Quality Assurance Project Plan for Remedial Action-Operations and Long-Term Management* (EA 2016a). Sampling at Area D will be conducted in accordance with the Final Remedial Design for Area D Groundwater (ARCADIS 2008b). *In situ* HPT groundwater sampling will be conducted in accordance with the procedures outlined below and in EA SOP047A. Field SOPs are included in Appendix B and field data forms and equipment manuals are included in Appendix C.

Groundwater Sampling

Groundwater sampling will be conducted in accordance with EA SOP013, SOP047, SOP047A, SOP048, and the HydraSleeve SOP included in Appendix B⁵.

HPT and In Situ Groundwater Sampling

As part of the Area D investigation, 15 HPT locations will be installed using a roto-sonic drill rig; five locations in the vicinity of the PRB to help determine mass flux into the PRB, and two transects of five boreholes to provide horizontal and vertical delineation of TCE in areas upgradient and downgradient of D-92-3. The HPT locations were selected based on historical sampling results as well as known data gaps (**Figure 17B-1**). The proposed HPT locations were selected to facilitate characterization of subsurface conditions in the vicinity of the PRB and central plume line; however, the locations of borings, total depth, and number may be adjusted based on field conditions. The total depths of each profiling location are anticipated to be 100 ft bgs, with the water table estimated to be 2-4.5 ft bgs near the PRB and 10-15 ft bgs near D-92-3. A maximum of five discrete *in situ* groundwater samples will be collected from each HPT location; one every 20 ft to refusal, targeting 100 ft bgs.

Soil borings for profiling will be installed using roto-sonic drilling methods, with the data acquisition tool integrated with the direct-push equipment. The profiling sensors will provide real-time hydrostratigraphic and physiochemical data as the tooling is advanced, including continuous conductivity measurements. —HPT uses an injection and pressure transducer system to add clean water at a low flow rate. The matrix back-pressure response is monitored and provides an indication of soil permeability. The pressure response is inversely proportional to

⁵ In addition to using a disposable sampling straw as detailed in the SOP, decontaminated scissors may be used to cut the top portion of the sleeve. Once cut, water from the sleeve can be poured directly into the appropriate sample container.

the soil permeability, with a higher back pressure indicating a low permeability and vice versa. A hydraulic head profile can also be determined for discrete intervals below the water table.

In situ groundwater samples will be collected via the integrated sampling screen/port at 20 ft intervals. To collect groundwater samples, the injection process is reversed to pull the groundwater to the surface where physiochemical parameters (pH, oxidation reduction potential [ORP], dissolved oxygen [DO], and specific conductance [SC]) will be recorded with a multi-parameter water quality meter, as per SOP-43. Purging will be conducted until physiochemical parameters indicate that a representative groundwater sample will be collected for laboratory analysis. Historical physiochemical parameters collected from nearby site wells will be used to help gauge the representativeness. Groundwater samples will be collected by directly filling sample containers provided by the analytical laboratory. Sample containers will be labeled, tracked via chain of custody forms, and packed and shipped to an offsite laboratory for analysis.

HPT sampling will begin at the ends of each transect, working toward the middle point. *In situ* groundwater samples will be sent offsite for analysis of VOCs using USEPA Method 8260B with quick turn-around time such that results from the end points can be used to adjust the remaining points in the transect if necessary (i.e., if CVOCs are detected in samples from the end of the transect, a mid-point can be relocated in order to capture the full width of the plume). Each sample will be labeled with the boring number and the collection depth (e.g., D-HPT-1A-20). Upon completion of hydrogeologic profiling, the borehole will be backfilled to the ground surface with a bentonite grout mixture. Hydraulic profiling will be performed under the full-time supervision of an EA field geologist. The driller will be responsible for logging all appropriate HPT information and the onsite geologist will record activities in a field logbook.

Monitoring Well Installation

Following the *in situ* groundwater sampling using HPT, four sets of clustered wells (shallow, mid, and deep) will be installed; two sets adjacent/southwest to D-PRB-09 to delineate CVOCs in groundwater southwest of the PRB, and two sets to provide definitive groundwater results in hot-spot areas in the vicinity of D-92-3. The screened intervals, depths, and locations of the well clusters will be based on the results of the HPT screening data and laboratory results from the *in situ* groundwater samples. A report will be provided under separate cover for approval/concurrence prior to commencement of well installation. Installation of the new wells will be performed under the full-time supervision of an EA field geologist and in accordance with EA SOP019/SOP019A.

Soil cuttings generated during monitoring well installation will be screened with a PID and disposed of as detailed in SOP042. Monitoring well clusters (MWC) will be numbered in order of installation, with a numbering system ranging from D-MWC-1 up to D-MWC-4. Shallow monitoring wells will be designated as “S” (e.g. D-MWC-1S), intermediate monitoring wells will be designated as “I” (e.g., D-MWC-1I), and deep monitoring wells will be designated as “D” (e.g., D-MWC-1D).

Since multiple surface water samples are to be collected from a surface water body, samples will be collected from the further point downstream, moving upstream as the sampling progresses. A description of the sampling point will be entered into the field logbook and the location will be recorded using a handheld global positioning system (GPS) unit. Surface water sampling of Green Pond Brook will be conducted mid-stream at mid-depth by submerging the sample bottles directly into the surface water body. The top of the bottle should be immersed several inches under the water to prevent floating debris or surface film from entering the sample container.

If it is not possible to collect the sample directly into the sample bottles (i.e., the surface water column is too shallow or floating debris interferes with the flow), the surface water will be collected into a stainless-steel pitcher, or a disposable bailer and decanted into the sample containers. If used, the stainless-steel pitcher will be decontaminated between uses at each unique sample location. Once collected, the surface water samples will be preserved, if required. Analytes to be measured include VOCs by USEPA Method 8260B.

Soil Sampling

While onsite for the hydraulic profiling portion of the Area D investigation, two soil borings will be advanced using the roto-sonic drill rig (**Figure 17B-2**) in accordance with EA SOP047. The two borings will be installed within the PRB to visually inspect for biofouling and silting that may be impacting PRB performance. The borings will be biased toward the upgradient side of the wall.

Soil cores will be collected continuously at each boring location using a dedicated acetate macro-core sleeves. Cores will be split open and personnel will record observations on boring logs, describing depth intervals and soil characteristics, including degree of cementation. Up to three samples will be collected in accordance with EA SOP025 from each core to be analyzed for VOCs by USEPA Method 8260C. Sample intervals will target areas of visual impact and/or areas that register the highest concentration on the PID. One sample from each core will also be submitted for iron oxyhydroxide (rust), calcium carbonate (chalk), and iron sulfide (pyrite) by Semi Quantitative X-Ray Diffraction (XRD) Analysis- Reference Intensity Ratio (RIR) method, and porosity analysis. Upon completion of soil borings and sampling efforts, soil cuttings will be placed back into the borehole or re-worked into the surrounding ground surface. Direct-push drill rods will be decontaminated between soil boring locations to prevent cross-contamination. Decontamination fluids will be containerized in 55-gallon drums for offsite disposal.

EA Engineering, Science, and Technology, Inc., PBC

Sample Locations	Matrix	Depth (ft bgs)	Type	Frequency/ Analytical Group	Sampling SOP	Rationale for Sampling Location
Up to six soil samples from within PRB: D-PRB-SO1A through C D-PRB-SO2A through C	Soil	To be determined in the field	Grab	2018: One round of VOC <u>and mineral/porosity</u> sampling	SOP025	Evaluate material within PRB.

QAPP Worksheet #19B & 30B: Sample Containers, Preservation, and Hold Times

Laboratory: SGS-Accutest Laboratories,
4405 Vineland Road, Suite C-15
Orlando, FL 32811
Point-of-Contact: ~~Andrea Colby~~ Ariel Hartney <~~Andrea.Colby~~ Ariel.Hartney@sgs.com>

List any required accreditations/certifications: DoD ELAP-Certified, New Jersey ELAP-Certified (Certifications provided in Appendix A; expire 12/15/2018 and 6/30/2019, respectively).

Sample Delivery Method: FedEx shipment.

Matrix	Analytical Group ¹	Concentration Level	Analytical and Preparation Method	Sample Volume	Containers (number, size, and type) ^{2,3}	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/analysis)	Data Package Turnaround
Aqueous	Ammonia by Automated Colorimetry	Various	USEPA 350.1/ GN104	250 ml	one 250 or one 500 ml HDPE	Cool 4°C ± 2°C, pH <2 with H ₂ SO ₄	28 days from collection to analysis	Standard – 15 Days
Solid	VOCs	Low	USEPA8260C, 5035A / MS016, OP020	5 grams per vial	1 volatile organic analyte (VOA) vial with MeOH, 2 VOA vials with Water	Freeze within 48 hours	14 days	Standard – 15 Days

1. The sample containers, preservation, and hold times for VOCs, methane/ethane/ethene, sulfate/sulfur, nitrate/nitrogen, dissolved iron, and manganese are provided in Worksheet #19 & 30 of the 2016 QAPP (EA 2016a).
2. Sample size is a minimum; the containers listed will be filled to compensate for any required re-analysis or re-extractions. For samples requiring MS/ MSD, containers listed should be tripled.
3. It should be noted that extra sample containers will be provided by the laboratory to account for the possibility of breakage during shipment or in the field prior to sampling.

QAPP Worksheet #20B: Field Quality Control Summary

The following table represents the sample numbers for the sampling events included in the Area D evaluation. QA/QC sample requirements are based on the number of samples collected at each individual sampling effort and media; because of this, the number of field duplicates and MS/MSD samples is not always 10 or 20 percent of the number of native samples presented in the table.

Matrix	Analyte/Analytical Group	Native Samples	Field Duplicates ^(a)	MS/MSD ^(b)	Field Equipment Blanks ^(c)	Trip Blanks ^(d)	Total Number of Samples to Lab
<i>In Situ</i> Groundwater	VOCs	75	8	4	4	4	95
Groundwater	VOCs	29	3	2	2	2	38
Groundwater	Biological reductive dechlorination parameters (methane/ethane/ethene, ammonia, sulfate/sulfur, nitrate/nitrogen, dissolved iron, and manganese)	6	1	1	1	Not applicable	9
Groundwater	Microbial community structure	3	Not applicable	Not applicable	Not applicable	Not applicable	3
Soil	VOCs	6	1	1	1	1	10
<u>Soil</u>	<u>Minerals & porosity</u>	<u>2</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>2</u>
Surface Water	VOCs	5	1	1	1	1	9
a. One field duplicate will be collected per 10 parent samples on a site by site basis. b. One MS/MSD sample will be collected per 20 parent samples on a site by site basis. c. One field-equipment blank will be collected per sampling event or every 5 percent of samples, at a minimum. d. One trip blank per sample cooler that includes VOC samples.							

QAPP Worksheet #23B: Analytical Standard Operating Procedures

SOP Number ^(a)	Title, Date, and URL (if available)	Definitive or Screening Data	Matrix/Analytical Group	SOP Option or Equipment Type	Modified for Project? Y/N
GN104GD	Ammonia analysis by gas diffusion, automated colorimetry Date: March 2017	Definitive	Water/Ammonia	Lachat QuickChem 8000	N
MS016	Analysis of Volatile Organics By GC/MS, 09/17	Definitive	<u>Soil</u> /VOC	GC/MS	N
a. Laboratory SOPs and QA Manual are included in Appendix A to this UFP-QAPP Addendum b. The analytical standard operating procedures for VOCs in groundwater, methane/ethane/ethene, sulfate/sulfur, nitrate/nitrogen, dissolved iron, and manganese are provided in Worksheet #23 of the 2016 QAPP (EA 2016a).					

QAPP Worksheet #37B: Data Usability Assessment**Identify personnel (organization and position/title) responsible for participating in the data usability assessment:**PM: Frank DeSantis, EACorporate QC Officer: Dave Santoro, EAProject Chemist: Dan Hinckley, EA

Describe how the usability assessment will be documented: Third party data validation will be performed on the data set. Any discrepancies affecting the data quality, as identified by the data validator, will be summarized in a data evaluation section within the after-action documents.

Summarize the data usability assessment process including statistics, equations, and computer algorithms that will be used to analyze the data:

<u>Step 1</u>	<u>Review the project's objectives and sampling design</u> <i><u>Review the key outputs defined during systematic planning (i.e., Project Quality Objectives or DQOs) to make sure they are still applicable. Review the sampling design for consistency with stated objectives. This provides the context for interpreting the data in subsequent steps.</u></i>
<u>Step 2</u>	<u>Review the data verification and data validation outputs</u> <i><u>Review available QA reports, including the data verification and data validation reports. Perform basic calculations and summarize the data (using graphs, maps, tables, etc.). Look for patterns, trends, and anomalies (i.e., unexpected results). Review deviations from planned activities (e.g., number and locations of samples, holding time exceedances, damaged samples, and SOP deviations) and determine their impacts on the data usability. Evaluate implications of unacceptable QC sample results.</u></i>
<u>Step 3</u>	<u>Verify the assumptions of the selected statistical method</u> <i><u>Verify whether underlying assumptions for selected statistical methods (if documented in the RA-O and LTM UFP-QAPP) are valid. Common assumptions include the distributional form of the data, independence of the data, dispersion characteristics, homogeneity, etc. Depending on the robustness of the statistical method, minor deviations from assumptions usually are not critical to statistical analysis and data interpretation. If serious deviations from assumptions are discovered, then another statistical method may need to be selected.</u></i>
<u>Step 4</u>	<u>Implement the statistical method</u> <i><u>Implement the specified statistical procedures for analyzing the data and review underlying assumptions. For decision projects that involve hypothesis testing (e.g., "concentrations of TCE in groundwater are below the action level") consider the consequences for selecting the incorrect alternative; for estimation projects (e.g., establishing a boundary for surface soil contamination), consider the tolerance for uncertainty in measurements.</u></i>
<u>Step 5</u>	<u>Document data usability and draw conclusions</u> <i><u>Determine if the data can be used as intended, considering implications of deviations and corrective actions. Discuss DOIs. Assess the performance of the sampling design and identify limitations on data use. Update the CSM and document conclusions. Prepare the data usability summary report which can be in the form of text and/or a table. Perform an evaluation of analytical results, mass flux analysis, PRB effectiveness. Complete a groundwater model to project TCE reduction timeframes and reduce the mass flux to the PRB.</u></i>

LUCs for soil and groundwater were implemented to control current and future activities that could result in unacceptable risk to human health, as detailed in the Final Remedial Action Work Plan (ARCADIS 2010b) and the 2015 Annual Land Use Certification Report (EA 2016b).

In accordance with the ROD, soils impacted with explosives at concentrations exceeding SCLs were excavated and disposed of at a permitted landfill. Excavation and offsite disposal of 600 cubic yards of impacted soil from Sites 40 and 157 (southern area) was conducted in September 2010. Further discussion of the 2010 soil remedial action is included within the Final Interim Remedial Action Report (ARCADIS 2011). LUCs are in place to control impacted media within Site 156 and are discussed in the 2016 Annual Land Use Certification Report (EA 2017a).

Following completion of removal activities from Sites 40 and 157, long-term monitoring of groundwater, surface water, and sediment was initiated in 2011 with annual sampling currently being conducted at Group 1 Sites 40, 157, and Picatinny Lake (EA 2017b). The annual sampling program currently consists of the collection of groundwater from 10 monitoring wells (five at Site 40, four at Site 157, and one upgradient well), and the collection of surface water and sediment from two locations in Picatinny Lake (79-SW/SD1 and 79-SW/SD2) (**Figure 10C-2**).

Typical groundwater elevations measured since 2010 indicate a generally easterly flow direction towards Picatinny Lake (EA 2017b). Groundwater elevation levels suggest that the water table at PICA-079 is fairly level, with a slight bulge at 40MW-6. Thus, groundwater flow is directed away from 40MW-6 towards Picatinny Lake.

As discussed in the Five-Year Review and the annual reports, groundwater, surface water and sediment monitoring data at Group 1 show that explosives may be discharging to Picatinny Lake above site cleanup levels. Post-removal action data collected from several shallow monitoring wells indicate that elevated concentrations of explosives (TNT and RDX) are fluctuating/persistent throughout Group 1 (EA 2017b). For example, TNT and RDX results from shallow well 40MW-1 are presented below.

Step 7: Develop the Plan for Obtaining Data

The approach to obtain data for this study is presented in Worksheet #17. Reporting and recommendations for the Group 1 evaluation will be provided separate from the Annual RA-O Report.

the sampling point will be entered into the field logbook. The description will be adequate for the sampling point to be located in the future (i.e., global positioning system coordinate).

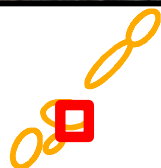
Soil Sampling

Soil samples will be collected from ~~22-15~~ locations, ~~nine-eight~~ locations at Site 157 and ~~13-seven~~ locations at Site 40 (**Figure 17C-1 and Figure 17C-2**), to identify any potential source areas that may be present in site soils. Soil samples will be collected through the use of a hand auger and/or geoprobe (for samples greater than 2 ft deep). The soil sampling locations were selected based upon current and historical activities associated with the handling/storage of explosive contaminated wastewater as well as systematic sampling along the shoreline. A site visit was conducted on 12 April 2018 with EA and installation personnel to evaluate current and former wastewater collections systems at the site. During the site visit, a former wastewater storage tank was observed adjacent to Building 823 (**Figure 17C-2**). Discussions with personnel in Building 809 indicated that this above ground tank historically held explosive-laden wastewater. Current storage of wastewater occurs in an 8 ft deep sub-surface storage tank at Building 809 (**Figure 17C-1**). The Army recently performed a leak evaluation of the Building 809 tank and determined the tank was functioning as designed (Environmental Office, personal communication).

Sediment Pore Water Sampling

Sediment pore water samples will be collected from 12 locations in Picatinny Lake and will be co-located with the surface water and sediment samples (**Figure 17C-1 and Figure 17C-2**).

Pore water samples will be collected through use of a PushPoint™ Sampler inserted at least 6 inches, targeting 8 to 10 inches below top of sediment, into the lake sediment along the shoreline as described in the USEPA Pore Water Sampling SOP (Number SESDPROC-513-R2, USEPA 2013). Pore water will be collected by connecting flexible tubing and using a peristaltic pump to extract pore water into laboratory containers.



Proposed Sampling Locations

- Soil Sampling Location
- Surface Water/Sediment/Porewater Sampling Location

0 75
Feet



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**Figure 17C-1
Group 1 (PICA-079)
Site 40
Sample Locations**



QAPP Worksheet #18C: Sampling Locations and Methods

Sample Locations	Matrix	Depth (ft bgs)	Type	Sampling SOP	Rationale for Sampling Location
79SB-01 through 79SB- 22 15	Soil	Various	Hand Auger or Geoprobe	SOP025, SOP048	Determine potential for current soils source areas
79PL-01 through 79PL-12	Surface Water	Mid-depth of location	Direct Fill/Grab	SOP007	Determine if surface water is impacted
79PL-01 through 79PL-12	Sediment Pore water	0.5 ft	PushPoint Sampler/Grab	USEPA SESDPROC- 513-R2	Determine if contaminated groundwater is discharging to Picatinny Lake
79PL-01 through 79PL-12	Sediment	0-0.5 ft and 1-2 ft	Multi-Stage Sampler/ Grab	SOP021	Determine if sediment is impacted

Table 18C-1: Group 1 Soil Sampling

Sample Location	Coordinates (NAD83 State Plane New Jersey)		Sample Depth(s) ^(b)	Explosives by USEPA 8330 ^(a)
	Northing	Easting		
Soil				
79SB-01	<u>772443.14</u>	<u>478281.63</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-02	<u>772390.87</u>	<u>478286.06</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-03	<u>772343.14</u>	<u>478322.87</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-04	<u>772286.68</u>	<u>478342.76</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-05	<u>772226.66</u>	<u>478350.06</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-06	<u>772185.79</u>	<u>478317.30</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-07	<u>772193.70</u>	<u>478266.61</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-08	<u>772147.69</u>	<u>478232.05</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-09	<u>772111.48</u>	<u>478182.40</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-10	<u>772094.88</u>	<u>478175.76</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-11	<u>772068.46</u>	<u>478163.24</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-12	<u>771995.85</u>	<u>478161.07</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-13	<u>772429.62</u>	<u>478244.47</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-14	<u>772362.69</u>	<u>478255.73</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
79SB-15	<u>772309.86</u>	<u>478286.43</u>	0-1 ft, <u>4-5ft, and 9-10ft</u>	X
a. Explosives contaminants of concern at Group 1 include 2-Amino-4,6-dinitrotoluene; 4-Amino-2, 6-dinitrotoluene; 2,4,6-dinitrotoluene; TNT, and RDX				
<u>b. The deepest interval at the sample location will be collected from 0-6 inches above the saturated zone.</u>				
NOTES: ft = Feet/foot. NAD83 = North American Datum of 1983. USEPA = U.S. Environmental Protection Agency.				

QAPP Worksheet #20C: Field Quality Control Summary

The following table represents the sample numbers for the Group 1 multi-media investigation. As noted previously, groundwater is monitored under the exiting RA-O program and is detailed in the 2016 UFP-QAPP (EA 2016a).

Matrix	Analyte/Analytical Group	Native Samples	Field Duplicates ^(a)	MS/MSD ^(b)	Equipment Blanks ^(c)	Total Number of Samples to Lab
Soil	Explosives	425	35	23	23	3256
Surface Water	Explosives	12	2	1	0	15
Sediment	Explosives	24	3	2	2	31
Sediment Pore Water	Explosives	12	2	1	1	16
a. One field duplicate will be collected per 10 parent samples on a site by site basis. b. One MS/MSD sample pair will be collected per 20 parent samples on a site by site basis. c. One equipment blank will be collected per 20 parent samples if non-dedicated sampling equipment is used.						

CHAPTER 4: BEAR SWAMP BROOK SAMPLING

QAPP Worksheet #10D: Conceptual Site Model

Bear Swamp Brook flows through the industrial portion of Picatinny. There are numerous buildings that border both Bear Swamp Brook and Green Pond Brook. In the past, many of these buildings had drains that discharged directly to the brooks. Currently, waste discharges to Green Pond and Bear Swamp Brooks no longer occur. The primary sources of contamination in Bear Swamp Brook are past industrial activities at adjacent sites and stormwater drainage. Past operational activities included production of explosives, rockets, munitions, propellants, pyrotechnic signals and flares, fuzes, and metal components.

Bear Swamp Brook drains an area of about 384 acres from its headwaters to the confluence with Green Pond Brook. The brook originates at an elevation of approximately 850 ft above mean sea level and travels on a 6.3 percent slope through a forested swamp habitat. The upper reaches of Bear Swamp Brook are characterized by a moderate steep narrow channel, fast flows, cool waters, and pool-run habitats. The channel bottom has a mixed fine-coarse sediment composition and the channel averages a width of four feet (Dames & Moore, 1998).

A relatively straight channel characterizes the lower reach of the brook. The average width of the lower brook is seven feet with an average flow rate of less than 0.05 cubic feet per second. The channel bottom generally has a fine sediment composition. The riparian habitat is variable with forested wetlands near the upper/lower reach transition zone. The stream becomes channeled underground via a culvert originating near the transportation facility's outdoor storage yard close to the junction of Reilly Road and Farley Avenue. It once again emerges and travels through the industrialized section of Picatinny. Numerous buildings in this section of Picatinny border Bear Swamp Brook. The compositions of the discharges from many of these buildings varied as the operations performed in each building were changed. Direct discharge of untreated effluent from these buildings was discontinued, as mentioned above.

The December 2004 ROD presents the selected remedies for contaminated sediment and surface water at Region 2, Region 3, and Region 4 of Green Pond Brook/Bear Swamp Brook (PICA-193). Under the Selected Remedy, Region 3 encompasses Bear Swamp Brook from Area H to the confluence with Green Pond Brook (**Figure 10D-1**). Elevated concentrations of metals, PCBs, pesticides, PAHs, and SVOCs were detected in sediment and surface water in Regions 2, 3, and 4 of Green Pond Brook and Bear Swamp Brook at Picatinny.

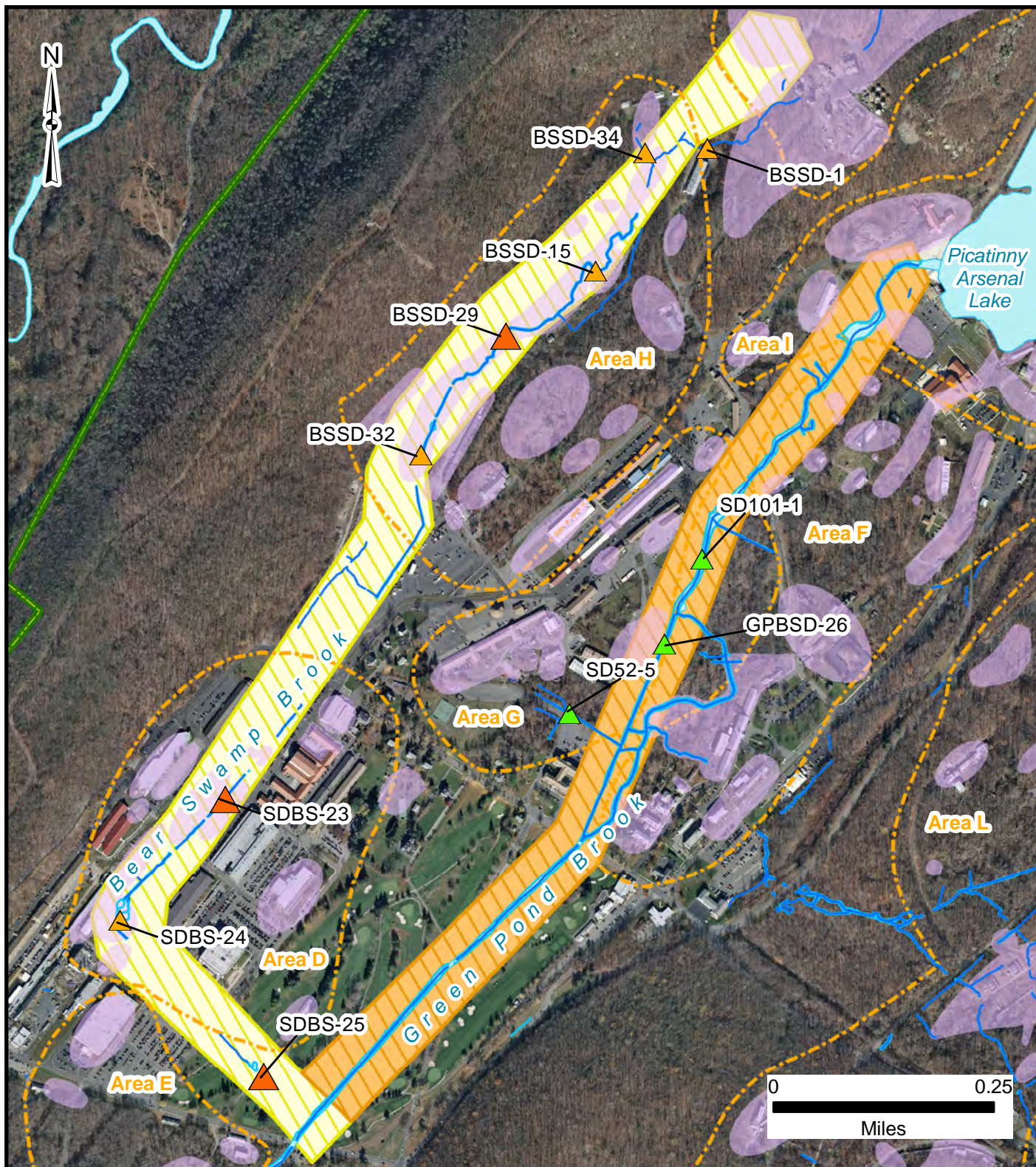
There have been two removal actions completed in Region 3. The first was the removal of PCB-laden sediment from the streambed and bank adjacent to Site 122 (Building 60) in early 2000. From January to May 2000, 387 cubic yards (580 tons) of soil and sediment were removed and disposed off-site (Shaw, 2003). The second removal action was the removal of sediment from the two sediment retention basins at Site 193, completed in 2003. Approximately 632 tons of stabilized sediment was disposed off-site as hazardous waste, and 386 tons of excavated soil was disposed as solid waste. These removal actions were documented in the Site 193 Bear Swamp Brook Sediment Removal Action As-Built Reports, March 31, 2005 (Shaw, 2005).

Excavation of a portion of Bear Swamp Brook, at the intersection of 4th Street and 3rd Avenue, occurred in the Summer of 2016 as part of a maintenance project to mitigate flooding (**Figure 10D-12**). The maintenance work involved clearing sediment from the brook to improve water flow. The excavated sediments were stockpiled and sampled to determine proper disposal procedures. Samples collected in July 2016 were analyzed for TCL VOCs by 8260C, SVOCs by 8270D, general chemistry, and full TCLP leachate (VOCs, SVOCs, herbicides, pesticides, and metals) in addition to PCBs. Elevated PCBs (124 milligrams per kilogram [mg/kg] total as Aroclor 1248) were observed in a composite sample from the less than 100 cubic yard stockpile. The SCL is the remedial action objective of 2 mg/kg total PCBs specified in the 2004 ROD (U.S. Army 2004b).

Subsequent sampling was conducted in the Fall of 2016 from nine locations adjacent to and downstream of the excavated area, sampled for PCBs only. Samples from four of these locations had concentrations of PCBs that were above the SCL, with the highest concentration observed in the furthest downstream location, ~~PBC~~PCB-9 (**Figure 10D-21**).

In 2017, sample location SDBS-23, sampled as part of the annual monitoring and located in the area of Bear Swamp Brook to be investigated (Figure 10D-3), did not have any COCs that exceeded their respective PEL/RGs. Metals concentrations have been generally stable since 2009. Between 2007 and 2017, there was one hit of 703 mg/kg Aroclor 1248, in 2010. PCBs were otherwise non-detect.

The 2016 sampling indicated that PCBs above SCLs remain in Bear Swamp Brook sediments in the vicinity of 4th Street and 3rd Avenue. Due to the PCB concentrations exceeding the allowable ROD cleanup levels, additional sampling is required to delineate the potential downstream and vertical extent of PCB impacts.

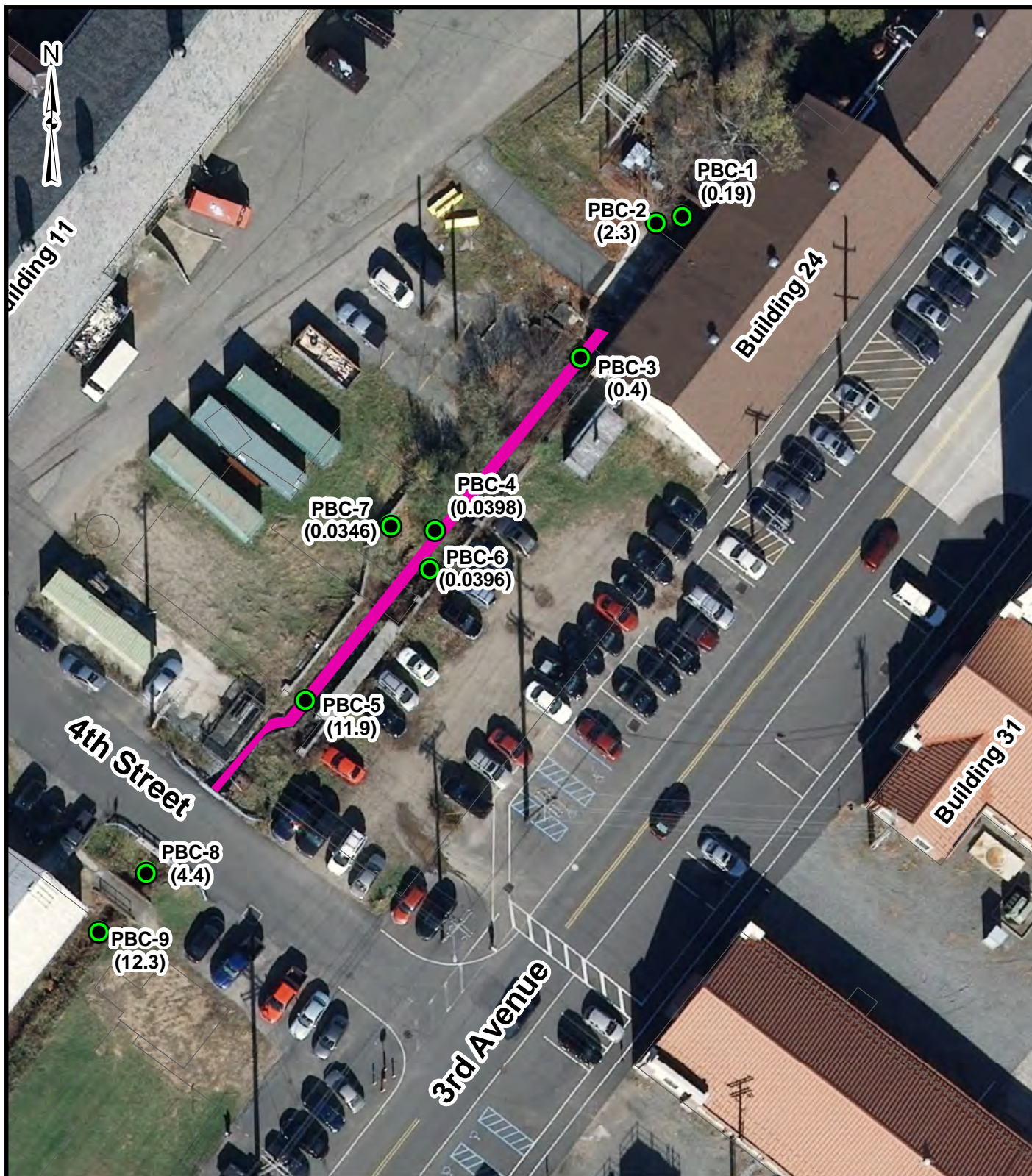


- Installation Boundary
- Region 2
- Region 3

- Region 3 Sediment Sample Location - Chemical Monitoring

- Historical Region 3 Sample Locations
- Region 2 Sample Locations

- Environmental Study Areas
- Environmental Sites



Type



2016 Sample Location



Approximate Excavation Area

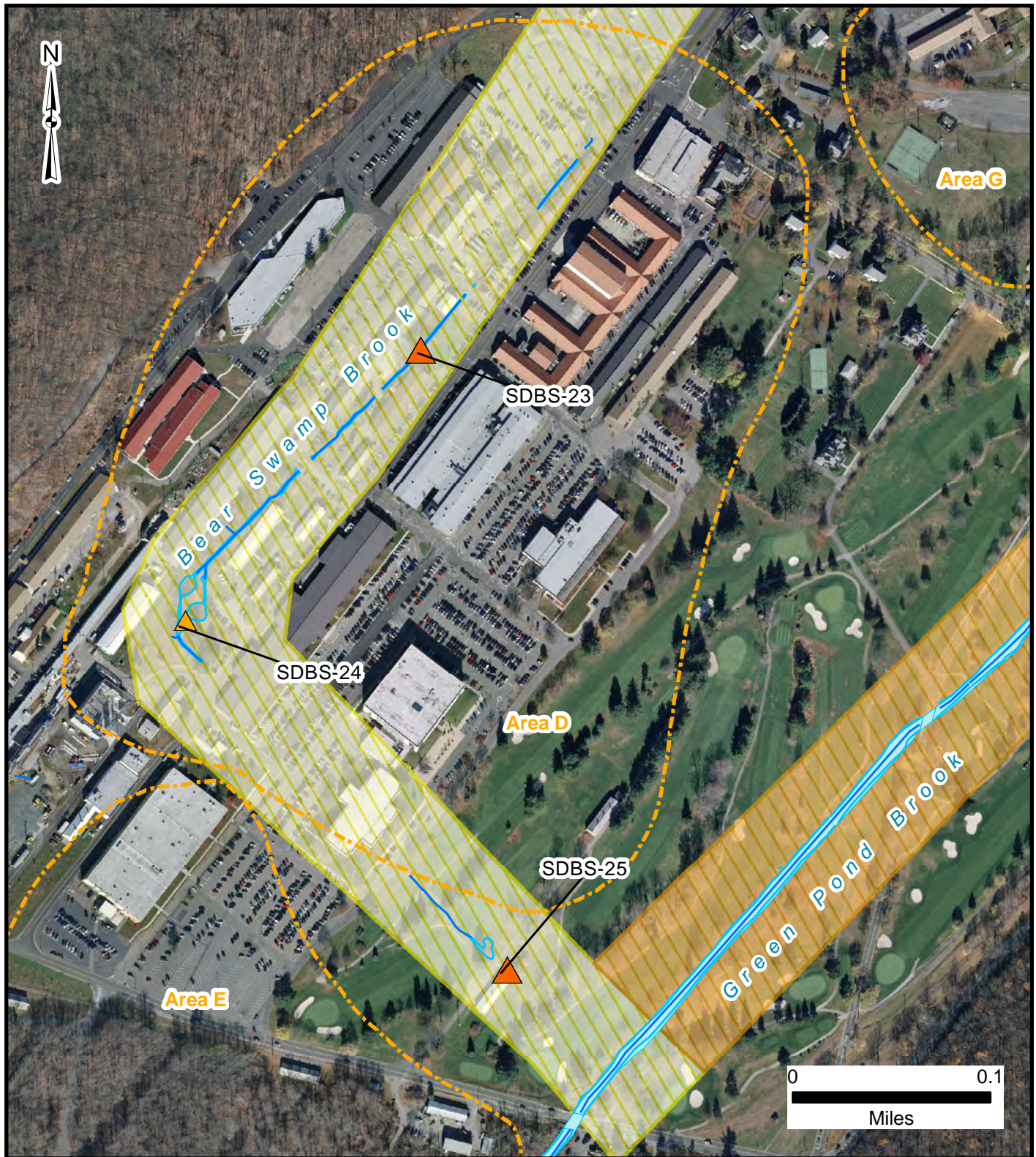
0 100
Feet

Note: Concentrations in mg/kg.
ROD cleanup level is 2 mg/kg



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Figure 10D-2
Bear Swamp Brook
Excavation Area and
2016 Total PCB Results (mg/kg)



- Installation Boundary
- Region 2
- Region 3

- Region 3 Sediment Sample Location - Chemical Monitoring
- Historical Region 3 Sample Locations
- Environmental Study Areas
- Environmental Sites

QAPP Worksheet #11D: Project/Data Quality Objectives

The Project/DQOs for the Bear Swamp Brook Sampling are outlined below. This worksheet follows USEPA's 7-step DQO process.

Step 1: State the Problem

The extent of PCB impact in Bear Swamp Brook sediments in the project area is unknown.

Step 2: Identify the Goal of the Study

The goal of this project is to determine the vertical and downstream extent of PCB contaminated sediment in Bear Swamp Brook.

Step 3: Identify the Information Inputs

PCB analytical data will be collected at distinct depth intervals (0-3 inches, 1 ft, and 3 ft) along the Bear Swamp Brook channel.

Step 4: Define the Boundaries of the Study

The boundary of the study is the Bear Swamp Brook channel from Building 24 downstream to Building 68 (**Figure 11D-1**). The primary sources of contamination in Bear Swamp Brook in this area are past industrial activities at adjacent sites and stormwater drainage. Past operational activities included production of explosives, rockets, munitions, propellants, pyrotechnic signals and flares, fuzes, and metal components.

Step 5: Develop the Analytical Approach

Sediment samples will be analyzed for PCBs using USEPA method 8082 as indicated in the 2016 UFP-QAPP (EA 2016a).

Step 6: Specify Performance or Acceptance Criteria

The analytical data will be defined as useable by the analytical laboratory's QC process, and the laboratory detection limits must be at or below evaluation criteria, if possible. Collected data need to be of adequate quality to make the decisions, and will be compared initially to action levels specified in Worksheet #15 of the 2016 UFP-QAPP (EA 2016a), which includes reference limits and evaluation criteria.

Step 7: Develop the Plan for Obtaining Data

The approach to obtain data for this study is presented in Worksheet #17. Reporting for the Bear Swamp Brook evaluation and recommendations will be provided separate from the Annual RA-O Report.

QAPP Worksheet #17D: Sampling Design and Rationale

Required sampling includes the collection of sediment samples for laboratory analysis of PCBs. The sampling design is intended to identify the vertical and downgradient extent of PCB impacted sediment in Bear Swamp Brook. Sample locations are described in Worksheet #18C.

Sediment Sampling

Sediment sampling will be conducted in accordance with EA SOP021 in Appendix B of the 2016 UFP-QAPP (EA 2016a). Prior to the collection of sediment samples in areas of potential UXO hazard, the area to be sampled will be screened for UXO by a qualified explosive ordnance disposal technician using a magnetometer. If the area is determined to be free of any ferrous metal objects, the sediment sampling will proceed. If a metal contact is made by the magnetometer, the location will be abandoned and new metal-free location will be found.

Sediment samples will be collected from 12 locations in Bear Swamp Brook (**Figure 17D-1**). Three grab samples will be collected from each location at depths of 0-3 inches, 1 ft, and 3 ft. The sediment sampling intervals target a shallow bioavailable zone, a mid-depth interval, and a deeper zone. Samples will be collected from downstream moving upstream using a multi-stage sampler and/or hand auger. Following removal of rocks, twigs, leaves, and other debris, the sediment will be homogenized. Once a consistent physical appearance over the homogenized sediment has been obtained, the sediment will be transferred into the appropriate sample container using disposable plastic scoops.

A description of properties for all sediment samples (color, texture, odor, organic content, grain size) will be recorded in the field logbook immediately after sample collection. A description of the sampling point will be entered into the field logbook. The description will be adequate for the sampling point to be located in the future (i.e., global positioning system coordinate).